

OPTICAL WASHING METHOD FOR PROJECTION OPTICAL SYSTEM FOR ALIGNER, AND ALIGNER AND METHOD FOR ALIGNING

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Abstract

PROBLEM TO BE SOLVED: To provide the aligner which can effectively remove contaminations sticking one a lens surface of the projection optical system of the aligner.

SOLUTION: The device is equipped with a convex lens 7 and a concave lens 8 which have focal length such focal length (f) that $f \leq d / [\tan(\sin^{-1}(NA_0)) - \tan(\sin^{-1}(NA_i))]$, where NA_i is the numerical aperture of a lighting optical system 3, NA_0 is the numerical aperture of the projection optical system 10, and (d) is the distance between the farthest lighting area from an optical axis 37 and the optical axis 37 at a mask arrangement position 6; and a holding device 9 holding the convex lens 7 and concave lens 8 is driven by a drive device 15 to arrange one of the convex lens 7 and concave lens 8 selectively at a position 6.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention relates to the optical washing approach, aligner, and the exposure approach of the optical system for aligners.

[0002]

[Description of the Prior Art] In recent years, high resolving is needed also for the projection aligner used for an optical lithography process with high integration of a semiconductor device. Therefore, the wavelength of the exposure light used with a projection aligner is becoming short, and, recently, the aligner which uses light with a wavelength of 200nm or less as an exposure light is also proposed.

[0003]

[Problem(s) to be Solved by the Invention] By the way, with the lens used for the aligner mentioned above, since the moisture and the organic system matter which are contained in air tend to have adhered to a lens front face, there was a problem that a lens front face will be polluted with these pollutants during an aligner production process and a maintenance. Since especially these pollutants have the property which absorbs light 200nm or less strongly, in the aligner using exposure light 200nm or less, decline in the permeability by the pollutant adhering to a lens front face poses a problem.

[0004] Thus, by irradiating ultraviolet rays on a lens front face, an adhesion pollutant secedes from a lens front face, and it is known that a lens front face will be washed effectively as the pollutant adhering to a lens front face is indicated by JP,7-294705,A. And since the exposure light 200nm or less used for an aligner was ultraviolet rays, it was effective in the pollutant adhering to a lens front face being washed by operating an aligner and irradiating exposure light at the lens of optical system.

[0005] However, since the numerical aperture (it is described as NA below) of the illumination-light study system generally used for a projection aligner is smaller than NA of projection optics, when incidence of the illumination light from an illumination-light study system is carried out to projection optics as it was, a part of NA field (field corresponding to NA of an illumination-light study system) of projection optics will be illuminated, and only the illuminated field will be washed. Therefore, the field where the washed permeability is high, and the field where the pollutant adhered and where permeability is low will exist in a lens front face, consequently the quantity of light nonuniformity of the image formation pattern by degradation of the resolution by the fall of the efficiency NA of projection optics or permeability nonuniformity arose, the image formation performance degradation of a projection aligner was imitated, and there was a problem of **.

[0006] The purpose of this invention is to offer the optical washing approach, aligner, and the exposure approach the pollutant adhering to the lens front face of the projection optics of an aligner is effectively removable.

[0007]

[Means for Solving the Problem] It matches and explains to drawing 1 which shows the gestalt of implementation of invention, and 8.

(1) Invention of claim 1 can attain the above-mentioned purpose by carrying out optical washing of the

lens side of the lens which constitutes projection optics 10 by illuminating projection optics 10 by flux of light B-2 which the flux of light B1 from the illumination-light study system 3 was made refracted by the optical members 7 and 8 which have refractive power, and was refracted by the optical members 7 and 8.

When it matches and explains to drawing 1 and 8, (2) Invention of claim 2 It is the positive lens 7 or negative lens 8 with which an optical member is arranged in object surface 6 location of projection optics 10 in the optical washing approach according to claim 1. When numerical aperture of the illumination-light study system 3 was set to NAi, numerical aperture of projection optics 10 was set to NAo and distance of the furthest lighting-on object surface field and furthest optical axis 37 from an optical axis 37 was set to d, the focal distance f of lenses 7 and 8 was set up like a degree type (4).

[Equation 4]

$$|f| \leq d / [\tan\{\sin^{-1}(NAo)\} - \tan\{\sin^{-1}(NAi)\}]$$

-- (4)

(3) Invention of claim 3 is applied to the aligner which has the illumination-light study system 3 which illuminates the mask with which the pattern was formed according to the flux of light from the light source 1, and the projection optics 10 which projects the flux of light which penetrated the mask on a photosensitive substrate, and attains the above-mentioned purpose by having formed the optical members 7 and 8 which the flux of light B1 from the illumination-light study system 3 is made refracted, and carry out incidence to projection optics 10 removable.

(4) Invention of claim 4 is the positive lens 7 or negative lens 8 with which an optical member is arranged in object surface 6 location of projection optics 10 in an aligner according to claim 3. When numerical aperture of the illumination-light study system 3 was set to NAi, numerical aperture of projection optics 10 was set to NAo and distance of the furthest lighting-on object surface field and furthest optical axis 37 from an optical axis 37 was set to d, the focal distance f of lenses 7 and 8 was set up like a degree type (5).

[Equation 5]

$$|f| \leq d / [\tan\{\sin^{-1}(NAo)\} - \tan\{\sin^{-1}(NAi)\}]$$

-- (5)

(5) The illumination-light study system 3 in which invention of claim 5 illuminates the mask with which the pattern was formed according to the flux of light from the light source 1, It is applied to the aligner which has the projection optics 10 which projects the flux of light which penetrated the mask on a photosensitive substrate. When numerical aperture of the illumination-light study system 3 is set to NAi, numerical aperture of projection optics 10 is set to NAo and distance of the furthest lighting field and furthest optical axis 37 from an optical axis 37 is set to d in the object surface 6 of projection optics 10, it is a degree type (6).

[Equation 6]

$$|f| \leq d / [\tan\{\sin^{-1}(NAo)\} - \tan\{\sin^{-1}(NAi)\}]$$

-- (6)

It has the lens migration equipments 9 and 15 which arrange alternatively the positive lens 7 and negative lens 8 which have the focal distance f to satisfy, or a positive lens 7 and a negative lens 8 in object surface 6 location of projection optics 10, and the above-mentioned purpose is attained.

(6) Set invention of claim 6 to the aligner of any one publication of claim 3-5. The amount measuring instrument 5 of incident light which measures the quantity of light of the flux of light which carries out incidence to projection optics 10, The outgoing radiation quantity of light measuring instrument 12 which measures the quantity of light of the flux of light by which outgoing radiation is carried out from projection optics 10, A permeability calculation means 13 to compute the permeability of projection optics 10 based on the measurement value of the amount measuring instrument 5 of incident light, and the outgoing radiation quantity of light measuring instrument 12, It has the control means 14 which controls alternative arrangement of the positive lens by attachment and detachment of an optical member, or the lens migration equipments 9 and 15, or a negative lens based on the permeability computed by the permeability calculation means 13. For example, a control means 14 controls

termination of optical washing, selection of a positive lens 7 or a negative lens 8, etc. based on permeability.

(7) Invention of claim 7 formed the supporting structure 9 and 15 which arranges alternatively either a mask and the optical members 7 and 8 in the mask arrangement location 6 within an optical path in the aligner according to claim 3.

(8) Invention of claim 8 illuminates the mask with which the pattern was formed with exposure light, is the optical washing approach of the optical system for aligners which carries out image formation of the pattern image on a photosensitive substrate, and attains the above-mentioned purpose by performing optical washing performed by irradiating the flux of light from the light source for optical washing in the lens side of the lens which constitutes optical system 10 in advance of the exposure actuation using a mask.

(9) In the optical washing approach of the optical system for aligners according to claim 8, replace invention of claim 9 with the light source for optical washing, and it irradiates the flux of light from the light source 1 for exposure in a lens side.

(10) In the optical washing approach of the optical system for aligners according to claim 9, invention of claim 10 arranges the optical members 7 and 8 which have refractive power in the optical path between the light sources 1 for exposure and optical system 10 which generate exposure light, makes the flux of light from the light source 1 for exposure refracted by the optical members 7 and 8, and irradiates a lens side.

(11) In the optical washing approach of the optical system for aligners according to claim 8 to 10, after starting the exposure of the flux of light to a lens side, invention of claim 11 will end optical washing, if the permeability of optical system 10 becomes beyond a predetermined value.

(12) The illumination-light study system 3 in which invention of claim 12 illuminates the mask with which the pattern was formed according to the flux of light from the light source 1, The projection optics 10 which projects the flux of light which penetrated the mask on a photosensitive substrate, The optical members 7 and 8 which it is prepared [members] possible [insertion and detachment] in the optical path between the light source 1 and projection optics 10, and make the flux of light from the light source 1 refracted, The detection equipments 5, 12, and 13 which detect the permeability of projection optics 10, and a calculation means 14 to compute the lighting nonuniformity on a photosensitive substrate by being based on the permeability detected with the detection equipments 5, 12, and 13, The storage 141 with which the time amount change property of the exposure light transmittance of projection optics 10 is memorized beforehand, It is the exposure approach of an aligner equipped with the control means 14 which controls the addition light exposure of the exposure light irradiated on a photosensitive substrate based on detection **** permeability and a time amount change property with the detection equipments 5, 12, and 13. (a) when the lighting nonuniformity of the exposure light on a photosensitive substrate exceeds predetermined default value After suspending the exposure actuation with a mask, replace with a mask and the optical members 7 or 8 are inserted into an optical path. Irradiate the flux of light refracted by the optical members 7 or 8 in the lens side of the lens which constitutes projection optics 10, and optical washing of a lens side is performed. (b) the permeability of projection optics 10 changes, and when lighting nonuniformity is below predetermined default value performing exposure using a mask, controlling addition light exposure by the control means 14 so that the addition light exposure on a photosensitive substrate becomes the optimal -- the above-mentioned purpose is attained by having made it like.

[0008] In addition, although drawing of the gestalt of implementation of invention was used by the term of above-mentioned The means for solving a technical problem explaining the configuration of this invention in order to make this invention intelligible, thereby, this invention is not limited to the gestalt of implementation of invention.

[0009]

[Embodiment of the Invention] Hereafter, the gestalt of operation of this invention is explained with reference to drawing 1 - drawing 12. Drawing 1 is drawing showing the outline configuration of the aligner by this invention. 2 is a beam matching unit which connects the light source 1 and the

illumination-light study system 3, and the laser beam which carried out incidence to the illumination-light study system 3 through the beam matching unit 2 branches to two optical paths with the half mirror 4 prepared in the middle of the illumination-light study system 3. The laser beam which penetrated the half mirror 4 is used as illumination light as it is, and, on the other hand, incidence of the laser beam reflected by the half mirror 4 is carried out to the amount measuring instrument 5 of incident light.

[0010] The optical member 7 for washing is arranged in the location 6 where it is the object surface of projection optics 10, and a mask is arranged. 8 is other optical members for washing, and the optical members 7 and 8 are held at the supporting structure 9, and can arrange either of the optical members 7 and 8 in the mask arrangement location 6 of an aligner by carrying out the rotation drive of the supporting structure 9 with a driving gear 15. In addition, although drawing 1 omitted and showed the mask, a mask is arranged in the mask arrangement location 6 when performing the exposure process of normal, without performing optical washing using the optical members 7 and 8. In addition, this mask is also held with the optical members 7 and 8 at the supporting structure 9.

[0011] After the flux of light B1 from the illumination-light study system 3 receives a refraction operation, serves as flux of light B-2 and passes projection optics 10 by the optical members 7 or 8, incidence of it is carried out to the outgoing radiation quantity of light measuring instrument 12 installed on the wafer stage 11. 13 is transmissometry equipment and the permeability from the half mirror 4 to the outgoing radiation quantity of light measuring instrument 12 is computed based on the signal of the amount measuring instrument 5 of incident light, and the outgoing radiation quantity of light measuring instrument 12. And by comparing the permeability and design permeability which were computed, the adhesion condition of the pollutant of projection optics 10 can be known, change of permeability is seen, the progress condition of optical washing can be seen or the timing of washing termination can be determined. 14 is a control device which performs those control, 141 is the storage section the data about exposure are remembered to be, and light exposure is controlled based on the data of the storage section 141 to mention later.

[0012] Drawing 2 is drawing showing the configuration of the illumination-light study system 3 of the equipment shown in drawing 1, and the part enclosed with an alternate long and short dash line is the illumination-light study system 3. Incidence of the light from the beam matching unit 2 shown in drawing 1 is carried out to the fly eye lens 301 as an optical integrator. Many lens elements are bundled, the fly eye lens 301 is constituted, and the light source (secondary light source) of a large number corresponding to the number of the lens elements which constitute it is formed in the outgoing radiation side side of the fly eye lens 301. The flux of light from the secondary light source of a large number formed of the fly eye lens 301 passes an aperture diaphragm 302, and branches to two optical paths by the half mirror 4, and incidence of the reflected light is carried out to the amount measuring instrument 5 of incident light. On the other hand, image formation of the transmitted light is carried out on the field diaphragm 305 for relay lenses 304a and 304b to restrict the exposure range. The light which passed the field diaphragm 305 is irradiated by the optical member 7 for washing arranged in the mask arrangement location 6 through the relay lens 306, the reflective mirror 307, and the Maine condensing lens 308. In addition, although the half mirror 4 has been arranged in the middle of the illumination-light study system 3 with the equipment shown in drawing 1, you may arrange not only between this but between the illumination-light study systems 3 and the optical members 7.

[0013] Next, the function of the optical members 7 and 8 for washing is explained. First, optical washing when not using the optical members 7 and 8 for washing is explained. Drawing 3 is drawing explaining the flux of light before and behind the mask arrangement location 6 (bundle of rays), and the upper part is [a lower part] a projection optics side in an illumination-light study system side from the mask arrangement location 6. 33, 34, and 35 are the chief ray of the flux of light which passes along the illustration left end of the exposure range on the mask arrangement location 6 in order, the chief ray of the flux of light which passes along an optical axis 37, and the chief ray of the flux of light passing through the illustration right end of the exposure range. Moreover, 33a and 33b are the beam of light which it receives and carries out incidence to the mask arrangement location 6 at an angle of the opening half width alpha of the illumination-light study system 3, the beam of light which carries out incidence

of 34a and the 34b to the mask arrangement location 6 at an angle of the opening half width alpha to a chief ray 34, and a beam of light which carries out incidence of 35a and the 35b at an angle of the opening half width alpha to a chief ray 35 chief ray 33. In addition, the numerical aperture of the illumination-light study system 3 is expressed as NAi, then $NAi = n \cdot \sin \alpha$. Here, n is an atmospheric refractive index.

[0014] Here, when the mask 30 is arranged in the mask arrangement location 6, light will be diffracted with a mask 30 and will also generate the diffracted light with the larger include angle from chief rays 33, 34, and 35 than the opening half width alpha. It is 33c, 33d, 34c, 34d and 35c which were shown with the broken line of drawing 3, and such the diffracted light, and 35d of diffracted lights with the include angle respectively equal to the opening half width beta of projection optics 10 from a chief ray is shown. As shown in drawing 4, among the diffracted lights produced with the mask 30, only the light below the opening half width beta of projection optics 10 can pass projection optics 10, and image formation of the include angle to an optical axis 37 is carried out on the photosensitive substrate 32 arranged on the wafer stage 11.

[0015] On the other hand, when there is no mask 30 in the mask arrangement location 6, the flux of light by the side of projection optics is the flux of light of the same opening half width alpha as an illumination-light study system side, as a continuous line shows. Therefore, when optical washing on the front face of a lens of projection optics is performed with exposure light, without arranging a mask 30 in the mask arrangement location 6, exposure light will not be irradiated by the lens front face included in drawing 3 and the part which gave the slash of 4, but, as for the part, optical washing will be performed.

[0016] The approach of diffusing the illumination light with the diffusion plate 40 arranged instead of the mask in the optical path as an approach of solving such a fault as shown in drawing 5 is proposed in the Japanese-Patent-Application-No. No. 155856 [nine to] official report. If the diffusion plate 40 is used, the diffused light 41 which has a bigger include angle than an include angle alpha will be acquired, and only the diffused light 41 which has an include angle below the angular aperture half width beta of projection optics will pass projection optics. Consequently, the lens side located to the field below the opening half width beta more greatly than the opening half width alpha can also perform optical washing.

[0017] On the other hand, in this invention, it was made to carry out optical washing of the lens side of the projection optics 10 which is in the field below the opening half width beta more greatly than the opening half width alpha by making the flux of light refracted by the optical members (for example, a convex lens, a concave lens, etc.) which have refractive power.

[0018] Drawing 6 is drawing having shown signs that each flux of light which makes 33, 34, and 35 a chief ray with the concave lens 8 for washing which is drawing explaining the case where the negative lens (a concave lens is called below) which has negative refractive power as an optical member for washing is used, and was arranged in the mask arrangement location 6 was refracted. The concave lens 8 for washing is arranged so that the medial axis and optical axis 37 of the principal plane 8a of a concave lens 8 may correspond in accordance with the mask arrangement location 6. The flux of light which makes 33 and 35 a chief ray is refracted so that it may keep away from an optical axis 37 with a concave lens 8. At this time, before refraction, the beams of light 33b and 35a whose include angles to an optical axis 37 were alpha set up the refractive power (focal distance) of a concave lens 8 so that after refraction may become equal to the opening half width beta of projection optics 10. In addition, about the setting approach of a focal distance, it mentions later.

[0019] It is drawing having shown signs that each flux of light which makes 33, 34, and 35 a chief ray with the convex lens 7 for washing arranged so that it might be drawing explaining the case where the positive lens (a convex lens is called below) which has refractive power forward [as an optical member for washing] in drawing 7 on the other hand is used and principal plane 7a might be in agreement with the mask arrangement location 6 was refracted. The flux of light which makes 33 and 35 a chief ray is refracted so that an optical axis 37 may be approached with a convex lens 7. At this time, the refractive power of a convex lens 7 is set up so that the include angle to the optical axis 37 of the beams of light 33a and 35b after refraction may become equal to the opening half width beta of projection optics. In

addition, the include-angle change theta of the beams of light 33a and 35b before and behind refraction is expressed like a degree type (7), when numerical aperture of an illumination-light study system and projection optics is set to NAiNAo, respectively.

[Equation 7]

$$\text{Theta} = \text{beta} - \text{alpha} = \sin^{-1}(NAo) - \sin^{-1}(NAi) \quad (7)$$

[0020] Next, with reference to drawing 8, the setting approach of the focal distance f of a concave lens 8 and a convex lens 7 is explained. In (a), in the case of the concave lens 8, in drawing 8, (b) shows the case of a convex lens 7. When the include-angle change theta arises like the beams of light 33b and 35a of drawing 6, and the beams of light 33a and 35b of drawing 7, since only theta is refracted mostly, below chief rays 33 and 35 set the include angle of refraction to theta, and a focal distance is set up. In drawing 8, F is the focus of a lens, is an intersection when extending the chief rays 33 and 35 after refraction at an illumination-light study system side (on illustration) in the case of a concave lens 8, and is the point that the chief rays 33 and 35 after refraction cross at a projection optics side (under illustration) in the case of a convex lens 7. If distance from the optical axis 37 of chief rays 33 and 35 is set to d, a focal distance fo will be given by the degree type (8).

[Equation 8]

$$|fo| = d / \tan\theta = d / [\tan\{\sin^{-1}(NAo)\} - \tan\{\sin^{-1}(NAi)\}]$$

-- (8)

In addition, in the case of the concave lens 8 which is a negative lens, it is focal distance $fo < 0$.

[0021] And what is necessary is just to set magnitude |fo| of the focal distance f of the optical member for washing below to |fo| of a formula (8). Drawing 9 is drawing showing signs that the flux of light (flux of light of chief rays 33 and 35) refracted with the concave lens 8 or convex lens 7 which is $f = fo$ passes projection optics 10, and image formation is carried out on the photosensitive substrate 32, and when (a) is a concave lens 8, it is the case where (b) is a convex lens 7. Although one lens showed projection optics 10, it consists of two or more lenses in fact, and by drawing 1, and 2 and 4, the case where lenses L1 and L2 are formed in the location as shown in drawing 9 is considered here. Although the fields R1 and R2 of the lens L2 shown in drawing 9 (a) turn into a field through which exposure light passes at the time of mask exposure at this time, when a concave lens 8 is used as an optical member for washing, it turns out that exposure light is not irradiated. Therefore, when a concave lens 8 is used as an optical member for washing, the fields R1 and R2 of a lens side cannot perform optical washing.

[0022] On the other hand, when a convex lens 7 is used as an optical member for washing like drawing 9 (b), it turns out that the exposure light for washing is not irradiated by the lens side of the fields R3 and R4 of a lens L1, and optical washing of the lens side of this field cannot be performed.

[0023] However, if a convex lens 7 is used, optical washing of the field of fields R1 and R2 will be carried out, and if a concave lens 8 is used, optical washing of the field of fields R3 and R4 will be carried out so that drawing 9 may also show. Thus, since there is a possibility that the lens side which cannot carry out optical washing by exposure light in either a concave lens 8 or the convex lens 7 depending on the lens configuration of projection optics 10 may come out, it is desirable to use both a concave lens 8 and the convex lens 7 by turns, and to perform optical washing.

[0024] When there is possibility of contamination on the front face of a lens by immediately after aligner manufacture, the time of mask exchange, the case as an aligner was not used for a long period of time, the maintenance of an aligner, etc., the optical members 7 and 8 for washing mentioned above before starting an exposure process are arranged in the mask arrangement location 6, exposure actuation is performed, and optical washing is carried out. At this time, transmissometry of projection optics is performed using measuring instruments 5 and 12, if it becomes extent to which the permeability of projection optics does not affect a process by the optical exposure of several hours from several minutes, while evacuating an optical member from the 6th page of a mask and arranging the mask for processes in the mask arrangement location 6, the sensitive substrate 32 is arranged on the wafer stage 11, and an exposure process is started. In addition, what is necessary is just to make it prepare in a projection optics side with the gestalt of operation mentioned above from the aperture diaphragm which may not necessarily be this location although the optical members 7 and 8 for optical washing were formed in the

mask arrangement location 6, is between projection optics 10 and the light source 1, and determines the numerical aperture of the illumination-light study system 3.

[0025] Subsequently, the concrete procedure of optical washing is explained. By the way, it is divided roughly into decline in the permeability of projection optics 10 by the thing resulting from decline in the permeability of the material of (1) lens itself, and the thing resulting from adhesion of the pollutant to (2) lens side. In the case of (1), the permeability of the whole lens falls to about 80%, but it is only that the fall of the illuminance on a photosensitive substrate takes place in this case, and lighting nonuniformity does not deteriorate. Also in the case of (2), when extent of contamination is light, the same phenomenon as (1) arises, but when extent of contamination is severe and a lens touches direct air for example, immediately after equipment manufacture and by optical-system maintenance etc., compared with the case where it is a lens without contamination, it is the worst, permeability falls to about 10%, and lighting nonuniformity degradation on the photosensitive substrate resulting from permeability nonuniformity occurs.

[0026] As mentioned above, when contamination becomes severe and lighting nonuniformity deteriorates, it is necessary to carry out optical washing of the whole lens at homogeneity. It is possible to amend change of permeability in the case of (1) or (2), on the other hand, by performing light exposure control which is described below, when contamination is slight. In addition, in measuring lighting nonuniformity, when the light exposure of each location of exposure within the limits is measured using the outgoing radiation quantity of light measuring instrument 12, the difference of the maximum at that time and the minimum value is taken out and this difference exceeds default value, it judges that lighting nonuniformity deteriorated and performs optical washing.

[0027] (Explanation of exposure by light exposure control) Drawing 10 is drawing showing the time amount change property of permeability when permeability irradiates a laser beam at the projection optics 10 which fell uniformly. Although permeability falls greatly immediately after exposure initiation of a laser beam, if it goes up gradually and time amount passes to some extent after that, it will be in a saturation state mostly. The phenomenon which depends the fall immediately after laser radiation initiation on change of the internal property of the ** material of a lens, and is recovered gradually after that is because the pollutant (water and organic substance) adhering to a lens side is removed by the exposure of a laser beam from a lens side.

[0028] With the gestalt of this operation, when an aligner is suspended a case so that the time amount change property of permeability as shown in drawing 10 may be beforehand memorized by the storage section 141, for example, an exposure activity may be interrupted on the way by exchange of a photosensitive substrate, and for a long time (about 10 hours), before starting an exposure activity again, measuring instruments 5 and 12 are used and transmissometry of projection optics is performed first. When the permeability at that time was set to A and exposure initiation (start time t0) is carried out again, permeability is presumed to change rightward from t0 of drawing 10. Then, based on the time amount change property memorized by storage 141, after exposure initiation adjusts the light exposure of the light source 1 so that the illuminance on an induction substrate may become suitable. Then, if permeability change becomes small (time of day at that time is set to t1, and permeability is set to B), it will shift to the usual exposure which does not perform light exposure control.

[0029] Drawing 11 is a flow chart which shows procedures, such as light exposure control exposure mentioned [which mentioned above and light-washed] above after aligner manufacture and a maintenance, and shows the procedure from exposure actuation initiation to termination. If an aligner is the step which judges ***** immediately after assembly and after a maintenance and are immediately after assembly and after a maintenance, step S1 progresses to step S2, and when that is not right, it will progress to step S11. When it progresses to step S2, after performing optical washing, the usual exposure which progresses to step S3 and does not carry out light exposure control is performed. In addition, the detailed procedure of optical washing is mentioned later. if it judges whether exposure was interrupted by step S4, it progresses to step S11 when interrupted, and is the step which judges whether exposure ended step S5 which progresses to step S5 and becomes YES, when not interrupted -- a series of exposure procedures -- ending -- NO -- return usual exposure is performed to the step [be / it] S3.

[0030] On the other hand, when it progresses to step S11 at step S1, if permeability judges whether it is permeability, fossete no, i.e., control [light exposure], from B of drawing 10 in step S11 and becomes YES about it, it will progress to step S12, and if it becomes NO, it will progress to step S3 and will usually expose. Step S12 is a step which judges whether lighting nonuniformity has deteriorated exceeding default value on a photosensitive substrate, when there is degradation of lighting nonuniformity, progresses to step S2, performs optical washing, and it is exposed, progressing to step S13 and carrying out light exposure control, when there is no lighting nonuniformity degradation. Step S14 is a step which judges whether the exposure time's having turned into beyond predetermined time (t_1-t_0) and permeability change became sufficiently small, and became more than B, if it becomes YES, will progress to step S3 and will usually be exposed by exposure from the next exposure. On the other hand, when judged with NO, it returns to step S11.

[0031] Next, the concrete procedure of optical washing performed at step S2 is explained, referring to drawing 12. At a process 1, N₂ gas (nitrogen gas) is purged especially between lenses in the lens-barrel which contains a lens immediately after equipment manufacture and after maintenance termination of optical system. If the optical member for optical washing of a concave lens is arranged in the mask arrangement location 6 within an optical path at the continuing process 2, exposure light will be irradiated at a process 3 in the lens side of projection optics 10, and optical washing will be performed. In this case, after arranging the optical member for optical washing of a concave lens in the mask arrangement location 6, the optical member for optical washing of a convex lens is arranged, exposure light is irradiated in the lens side of projection optics 10, and optical washing is performed. At a process 4, transmissometry of projection optics 10 is performed using measuring instruments 5 and 12, and if the measured permeability becomes beyond a predetermined value (B of drawing 10), optical washing will be completed. Moreover, in being smaller than the predetermined value B, it performs optical washing until permeability becomes beyond the predetermined value B.

[0032] With the gestalt of this operation mentioned above, it becomes possible to illuminate the whole numerical-aperture NAo field of projection optics 10 by making the illumination light for exposure refracted using the concave lens 8 and convex lens 7 which are an optical member for washing. Consequently, the pollutant adhering to the lens side of a numerical-aperture NAo field is removable by optical washing by exposure light. Moreover, with the gestalt of this operation, since the whole numerical-aperture NAo field is illuminated by making the flux of light refracted, there is no quantity of light reduction like the approach of diffusing the illumination light using the diffusion plate mentioned above, and optical washing can be performed more effectively.

[0033] In addition, although the gestalt of operation mentioned above explained the case where a concave lens 8 and a convex lens 7 were used as an optical member for washing, the optical member which has not only this but forward or negative refractive power can be used. Moreover, you may make it have prepared in the illumination-light study system side by using as the optical member for washing the reflective mirror which has refractive power. Furthermore, in the gestalt of this operation, an optical cleaning effect can be heightened more by setting up the numerical aperture of an illumination-light study system more than the effective diameter of optical elements, such as a lens which constitutes projection optics. Moreover, the light source for optical washing is established apart from the light source for exposure, and it may be made to perform optical washing using the light of the light source for optical washing. However, it is desirable to use the light source which carries out outgoing radiation of the light of wavelength almost equal to the wavelength of exposure light in this case. With the gestalt of operation mentioned above, although the case where ArF laser was used as an exposure light was explained, this invention can be applied also to the aligner which used EUVL(s), such as soft X ray with still shorter wavelength, further again.

[0034] correspondence with the gestalt of operation and the element of a claim which were explained above -- setting -- the supporting structure 9 and a driving gear 15 -- lens migration equipment -- transmissometry equipment 13 -- a permeability calculation means -- the storage section 141 constitutes storage and, as for measuring instruments 5 and 12 and transmissometry equipment 13, a control unit 14 constitutes detection equipment for a calculation means and a control means, respectively.

[0035]

[Effect of the Invention] As explained above, even if it is the case that the numerical aperture of an illumination-light study system is smaller than the numerical aperture of projection optics according to this invention The whole surface of the lens side field (numerical-aperture field) corresponding to the numerical aperture of projection optics can be illuminated without reducing the quantity of light of the flux of light by refracting the flux of light from an illumination-light study system by the optical member. The pollutant adhering to the numerical-aperture field of a lens side is effectively removable with optical washing. Since an optical member can be constituted from a positive lens and a negative lens and a positive lens and a negative lens can be especially used alternatively according to the lens configuration of projection optics according to invention of claim 5, optical washing of the whole numerical-aperture field of the lens side of projection optics can be carried out irrespective of the lens configuration of projection optics. According to invention of claim 7, since it was made to both arrange in a mask arrangement location alternatively, the time amount which holds a mask and an optical member by the supporting structure and which optical washing takes can be shortened. Since it was made to expose according to claim 12, performing (a) light washing or control of (b) addition light exposure according to extent of lighting nonuniformity, highly precise exposure can be performed.

[Translation done.]